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Department of Water Resources

FINAL REPORT
PROJECT EFFECTS ON PREDATION OF FEATHER RIVER JUVENILE ANADROMOUS SALMONIDS
SP-F21 TASK 3

Oroville Facilities Relicensing
FERC Project No. 2100

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INTERIM REPORT PROJECT EFFECTS ON PREDATION OF FEATHER RIVER JUVENILE ANADROMOUS SALMONIDS SP-F21 TASK 3

Oroville Facilities Relicensing FERC Project No. 2100

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REPORT SUMMARY

The purpose of SP-F21 Task 3 is to summarize existing literature on predation of juvenile anadromous salmonids associated with artificial structures and hydropower project operations in river systems other than the Feather River, and determine their applicability to the Feather River. In addition, any available literature on the effects of the Oroville Facilities and operations on predation of juvenile anadromous salmonids in the lower Feather River was evaluated. Ongoing operation of the Oroville Facilities has the potential to influence the level of predation on juvenile anadromous salmonids in the Feather River downstream from the Fish Barrier Dam. Operations of the Oroville Facilities affect flow and water temperature regimes and may create in-river conditions favorable for predators of juvenile anadromous salmonids. The results of this study provide information on the likely effects on the level of predation on juvenile anadromous salmonids associated with project structures and operations.

A review of available literature was conducted to investigate the potential for predation on juvenile anadromous salmonids associated with artificial structures and project operations in the lower Feather River and in other rivers containing hydropower facilities. Comparisons of species composition, in-river conditions and artificial structures, and operations that alter natural conditions were used to assess applicability of other river systems to the Oroville project and the lower Feather River.

Most studies on predation of juvenile anadromous salmonids associated with dam operations focus on juvenile fish bypass facilities. According to the body of available literature, high predation rates at most hydropower facilities generally are a result of unnaturally high concentrations of juveniles, stress related to passage through the facilities, and disorientation of juveniles associated with passing through the facilities. Although the Oroville project does not currently contain facilities for juvenile fish passage, similar conditions can be created by project operations and facilities. For example, the Fish Barrier Dam, which forces most anadromous salmonid spawning to occur in the Low Flow Channel (LFC) contributes to high concentrations of juvenile salmonids. Additionally, high flow events at the Thermalito Afterbay Outlet may create turbulent conditions disorienting juvenile salmonids, making them more susceptible to predation.

Water temperatures reportedly appear to be the most significant factor in determining species compositions in the lower Feather River (Seesholtz et al. 2003). Counts of known predators on juvenile anadromous salmonids are reported to be very low in the LFC (Seesholtz et al. 2003). Naturally spawned steelhead are an exception because little is known about their relative abundance. Because water temperatures are relatively low in the LFC, it is doubtful that significant predation occurs in the reach by non-salmonid species. Significant numbers of predators reportedly do exist in the High Flow Channel (HFC) below the Thermalito Afterbay Outlet, however (Seesholtz et al. 2003). Based on the relative abundance of predatory species in the HFC, it can be assumed that some predation on juvenile anadromous salmonids occurs in the reach.

One aspect of the Oroville Project operations and facilities that may enhance predation in the HFC is that the high density of juvenile salmonids in the LFC may cause early emigration of juvenile salmonids. Because juvenile rearing habitat in the LFC is limited, juveniles may be forced to emigrate from the area early due to competition for resources. Relatively small juvenile salmonids may be less capable of avoiding predators than those that rear to a larger size in the LFC prior to beginning their seaward migration through the HFC.

Recent studies have shown high numbers of juvenile Chinook salmon emigrating from the lower Feather River (Seesholtz et al. 2003). At the same time, high spawning escapements, equivalent to pre-dam years, reportedly have been observed (Yoshiyama et al. 2000). Additionally, a review of the literature indicates that environmental conditions in the lower Feather River are less suitable than those reported in the body of literature as optimal for predators of anadromous salmonids, particularly during the peak out-migration period. Analysis of coded wire tag (CWT) recovery data suggests that mortality of hatchery reared Feather River Chinook salmon released in the Feather River is high, but is very similar to mortality observed at downstream locations, beyond potential project effects. Therefore, it does not appear likely that continued operation of the Oroville Facilities, under current operating conditions, would create conditions favoring unnaturally high predation rates on juvenile anadromous salmonids in the lower Feather River. However, multiple confounding variables such as differences in river size, water temperature regimes, and migration distance between the Sacramento and Feather rivers makes interpretation of the differences in survival rates between juvenile Chinook salmon released at different locations difficult

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1.0 INTRODUCTION

1.1 BACKGROUND INFORMATION

Ongoing operation of the Oroville Facilities has the potential to influence the level of predation on juvenile anadromous salmonids in the Feather River downstream from the Fish Barrier Dam. Operation of the Oroville Facilities affects flow and water temperature regimes and may create in-river conditions favorable for predators of juvenile anadromous salmonids (NOAA 2000; Poe et al. 1991; Poe 1986) As a component of study plan (SP)-F21*, Project Effects on Predation of Feather River Juvenile Anadromous Salmonids*, Task 3, herein, summarizes existing literature on predation of juvenile anadromous salmonids associated with artificial structures and project operations in other river basins and determines their applicability to the Feather River.

1.1.1 Statutory/Regulatory Requirements

The purpose of SP-F21 Task 3 is to summarize literature on predation of juvenile anadromous salmonids associated with artificial structures and project operations in other river basins and to determine their applicability to the Feather River. Salmonids present in the lower Feather River include spring-run Chinook salmon (*Oncorhynchus tshawytscha*), fall-run Chinook salmon (*O. tshawytscha*), and steelhead (*O. mykiss*). On September 16, 1999, naturally-spawned Central Valley spring-run Chinook salmon were listed as threatened under the federal Endangered Species Act (ESA) by the United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NOAA Fisheries) (NOAA 1999). The Central Valley spring-run Chinook salmon Evolutionarily Significant Unit (ESU) includes all naturally-spawned populations of spring-run Chinook salmon in the Sacramento River and its tributaries, which includes naturally-spawned spring-run Chinook salmon in the lower Feather River (NOAA 1999). On March 19, 1998, naturally-spawned Central Valley steelhead were listed as threatened under the federal ESA by NOAA Fisheries (NOAA 1998). The Central Valley steelhead ESU includes all naturally-spawned populations of steelhead in the Sacramento and San Joaquin rivers and their tributaries, which includes naturally-spawned steelhead in the lower Feather River (NOAA 1998). The results and recommendations from this study fulfill, in part, statutory and regulatory requirements mandated by the ESA as it pertains to Central Valley spring-run and fall-run Chinook salmon.

In addition to the ESA, Section 4.51 (f)(3) of 18 CFR requires reporting of certain types of information in the Federal Energy Regulatory Commission (FERC) application for license of major hydropower projects, including a discussion of the fish, wildlife, and botanical resources in the vicinity of the project (FERC 2001). The discussion is required to identify the potential impacts of the project on these resources, including a description of any anticipated continuing impact for on-going and future operations.

As a subtask of SP-F21, Task 3 fulfills a portion of the FERC application requirements by detailing the potential effects of project operations on enhancing predation of juvenile anadromous salmonids in the Feather River. In addition to fulfilling these requirements, information collected during this task may be used in developing or evaluating potential Resource Actions.

1.1.2 Study Area

1.1.2.1 Description

SP-F21 Task 3 evaluated artificial structures and habitat alterations associated with project facilities and operations, which may create in-river conditions favorable for predators of anadromous salmonids. As a result, the geographic area to which the results of this report would be applied includes those areas in which operation of the Oroville Facilities may influence predation on juvenile anadromous salmonids. Consideration of the potential effects of artificial project structures and project operations on predation of juvenile anadromous salmonids included the Thermalito Afterbay Outlet, the Fish Barrier Dam, and the Feather River Fish Hatchery outlet. The potential effects of the current water temperature regime on predation of juvenile anadromous salmonids were analyzed for the lower Feather River from the Fish Barrier Dam to the confluence with the Yuba River because the confluence of the Feather and Yuba rivers currently is considered the downstream extent at which reasonable control of Feather River water temperatures could be obtained by operation of the Oroville Facilities (DWR 2002). The potential effects of the current flow regime, including minimum flow standards, on predation of juvenile anadromous salmonids were analyzed in the lower Feather River from the Fish Barrier Dam to the confluence with the Sacramento River because flows released into the lower Feather River as a result of project operations could influence the stage elevation and water velocity from the Fish Barrier Dam to the mouth of the Feather River.

1.1.2.2 History

Construction on the Oroville Dam began in 1961 and was completed in 1968. It is a zoned, earthfill dam with a height of 770 feet and a crest of 6,920 feet. The crest of the dam is at an elevation of 922 feet above sea level. The dam's spillway has two separate elements: a controlled gated outlet and an emergency uncontrolled spillway. The gated control structure is designed to allow controlled releases of up to 150,000 cubic feet per second (cfs) into a concrete chute leading to the river. The emergency uncontrolled spillway is designed so that if the reservoir fills above 901 feet, water could flow down the undeveloped canyon slope to the river (DWR 2001).

The Thermalito Diversion Dam was constructed between 1963 and 1968. The dam is located approximately four miles downstream from the Lake Oroville Dam. The dam is a 625-foot long concrete gravity dam with a regulated ogee spillway that releases water to the LFC of the Feather River. Water not released to the LFC is diverted into the Thermalito Power Canal leading to the Thermalito Forebay and then to the Thermalito Pumping-Generating Plant for power generation (DWR 2001).

The Fish Barrier Dam was constructed between 1962 and 1964. Because the dam is located upstream from the Feather River Hatchery, upmigrating anadromous salmonids are diverted into the fish ladder leading to the Feather River Fish Hatchery (FRFH). The Fish Barrier Dam currently defines the upstream migratory extent of anadromous salmonids in the Feather River (DWR 2001). In addition to blocking upstream migration of anadromous salmonids, the Fish Barrier Dam has caused the formation of a plunge pool at the base of the dam.

The Thermalito Afterbay Dam was constructed between 1965 and 1968. The dam is earth-filled with a crest of 42,000 feet (the longest in the SWP system) and a height of 39 feet. The dam impounds the Thermalito Afterbay and releases water to the Thermalito Afterbay Outlet, which defines the downstream extent of the LFC and the upstream extent of the HFC of the Feather River. The Thermalito Afterbay provides for multiple uses including: 1) provide storage for water required for pump-back operations to Lake Oroville; 2) help regulate the power system; 3) produce controlled flow in the feather River downstream from the Oroville Thermalito Facilities; 4) provide recreational opportunities; and 5) serve as a warming basin for agricultural water diverted to farms east of the Afterbay (DWR 2001). Operation of the Thermalito Afterbay Outlet has created a plunge pool at the afterbay outfall.

The Feather River Fish Hatchery, completed in 1967, was built for the primary purpose of compensating for spawning grounds lost to Chinook salmon and steelhead with the construction of the Oroville Dam (DWR 2001). The hatchery currently spawns and raises Chinook salmon and steelhead for release into the Feather River, transport and release to San Pablo Bay, and the stocking of other California reservoirs.

1.2 DESCRIPTION OF FACILITIES

The Oroville Facilities were developed as part of the State Water Project (SWP), a water storage and delivery system of reservoirs, aqueducts, power plants, and pumping plants. The main purpose of the SWP is to store and distribute water to supplement the needs of urban and agricultural water users in northern California, the San Francisco Bay area, the San Joaquin Valley, and southern California. The Oroville Facilities are also operated for flood management, power generation, to improve water quality in the Delta, provide recreation, and enhance fish and wildlife.

FERC Project No. 2100 encompasses 41,100 acres and includes Oroville Dam and Reservoir, three power plants (Hyatt Pumping-Generating Plant, Thermalito Diversion Dam Power Plant, and Thermalito Pumping-Generating Plant), Thermalito Diversion

Dam, the Feather River Fish Hatchery and Fish Barrier Dam, Thermalito Power Canal, Oroville Wildlife Area (OWA), Thermalito Forebay and Forebay Dam, Thermalito Afterbay and Afterbay Dam, and transmission lines, as well as a number of recreational facilities. An overview of these facilities is provided on Figure 1.2-1. The Oroville Dam, along with two small saddle dams, impounds Lake Oroville, a 3.5-million-acre-feet (maf) capacity storage reservoir with a surface area of 15,810 acres at its normal maximum operating level.

The hydroelectric facilities have a combined licensed generating capacity of approximately 762 megawatts (MW). The Hyatt Pumping-Generating Plant is the largest of the three power plants with a capacity of 645 MW. Water from the six-unit underground power plant (three conventional generating and three pumping-generating units) is discharged through two tunnels into the Feather River just downstream of Oroville Dam. The plant has a generating and pumping flow capacity of 16,950 cfs and 5,610 cfs, respectively. Other generation facilities include the 3-MW Thermalito Diversion Dam Power Plant and the 114-MW Thermalito Pumping-Generating Plant.

Thermalito Diversion Dam, four miles downstream of the Oroville Dam creates a tail water pool for the Hyatt Pumping-Generating Plant and is used to divert water to the Thermalito Power Canal. The Thermalito Diversion Dam Power Plant is a 3-MW power plant located on the left abutment of the Diversion Dam. The power plant releases a maximum of 615 cubic feet per second (cfs) of water into the river.

The Power Canal is a 10,000-foot-long channel designed to convey generating flows of 16,900 cfs to the Thermalito Forebay and pump-back flows to the Hyatt Pumping-Generating Plant. The Thermalito Forebay is an off-stream regulating reservoir for the 114-MW Thermalito Pumping-Generating Plant. The Thermalito Pumping-Generating Plant is designed to operate in tandem with the Hyatt Pumping-Generating Plant and has generating and pump-back flow capacities of 17,400 cfs and 9,120 cfs, respectively. When in generating mode, the Thermalito Pumping-Generating Plant discharges into the Thermalito Afterbay, which is contained by a 42,000-foot-long earth-fill dam. The Afterbay is used to release water into the Feather River downstream of the Oroville Facilities, helps regulate the power system, provides storage for pump-back operations, and provides recreational opportunities. Several local irrigation districts receive water from the Afterbay.

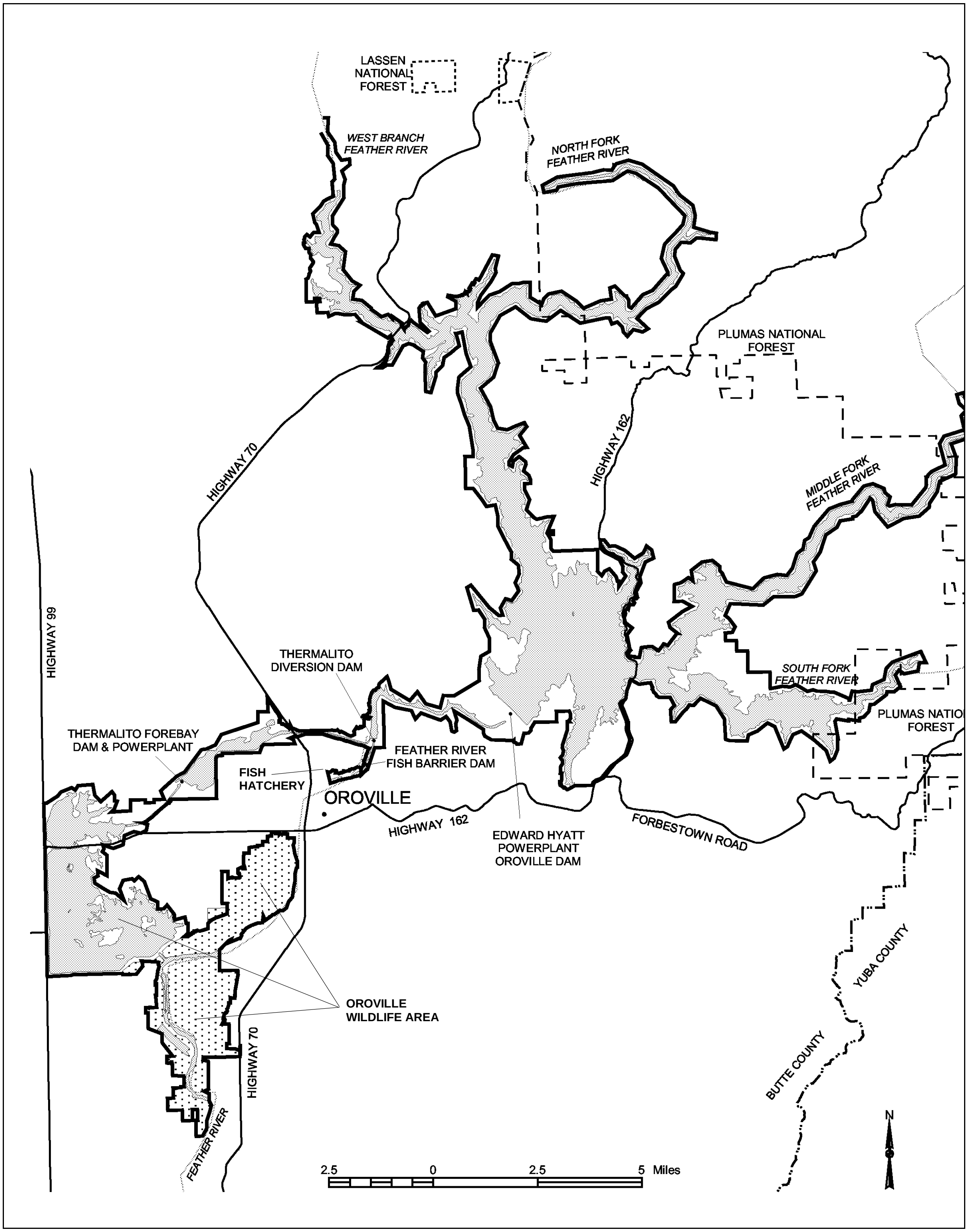

Figure 1.2-1. Oroville Facilities FERC Project Boundary.

The Feather River Fish Barrier Dam is downstream of the Thermalito Diversion Dam and immediately upstream of the Feather River Fish Hatchery. The flow over the dam maintains fish habitat in the low-flow channel of the Feather River between the dam and the Afterbay outlet, and provides attraction flow for the hatchery. The hatchery was intended to compensate for spawning grounds lost to returning salmon and steelhead trout from the construction of Oroville Dam. The hatchery can accommodate an average of 15,000 to 20,000 adult fish annually.

The Oroville Facilities support a wide variety of recreational opportunities. They include: boating (several types), fishing (several types), fully developed and primitive camping (including boat-in and floating sites), picnicking, swimming, horseback riding, hiking, off-road bicycle riding, wildlife watching, hunting, and visitor information sites with cultural and informational displays about the developed facilities and the natural environment. There are major recreation facilities at Loafer Creek, Bidwell Canyon, the Spillway, North and South Thermalito Forebay, and Lime Saddle. Lake Oroville has two full-service marinas, five car-top boat launch ramps, ten floating campsites, and seven dispersed floating toilets. There are also recreation facilities at the Visitor Center and the OWA.

The OWA comprises approximately 11,000-acres west of Oroville that is managed for wildlife habitat and recreational activities. It includes the Thermalito Afterbay and surrounding lands (approximately 6,000 acres) along with 5,000 acres adjoining the Feather River. The 5,000 acre area straddles 12 miles of the Feather River, which includes willow and cottonwood lined ponds, islands, and channels. Recreation areas include dispersed recreation (hunting, fishing, and bird watching), plus recreation at developed sites, including Monument Hill day use area, model airplane grounds, three boat launches on the Afterbay and two on the river, and two primitive camping areas. California Department of Fish and Game’s (DFG) habitat enhancement program includes a wood duck nest-box program and dry land farming for nesting cover and improved wildlife forage. Limited gravel extraction also occurs in a number of locations.

1.3 CURRENT OPERATIONAL CONSTRAINTS

Operation of the Oroville Facilities varies seasonally, weekly and hourly, depending on hydrology and the objectives DWR is trying to meet. Typically, releases to the Feather River are managed to conserve water while meeting a variety of water delivery requirements, including flow, temperature, fisheries, recreation, diversion and water quality. Lake Oroville stores winter and spring runoff for release to the Feather River as necessary for project purposes. Meeting the water supply objectives of the SWP has always been the primary consideration for determining Oroville Facilities operation (within the regulatory constraints specified for flood control, in-stream fisheries, and downstream uses). Power production is scheduled within the boundaries specified by the water operations criteria noted above. Annual operations planning is conducted for multi-year carry over. The current methodology is to retain half of the Lake Oroville storage above a specific level for subsequent years. Currently, that level has been established at 1,000,000 acre-feet (af); however, this does not limit draw down of the reservoir below that level. If hydrology is drier than expected or requirements greater than expected, additional water would be released from Lake Oroville. The operations plan is updated regularly to reflect changes in hydrology and downstream operations. Typically, Lake Oroville is filled to its maximum annual level of up to 900 feet above mean sea level (msl) in June and then can be lowered as necessary to meet downstream requirements, to its minimum level in December or January. During drier years, the lake may be drawn down more and may not fill to the desired levels the following spring. Project operations are directly constrained by downstream operational constraints and flood management criteria as described below.

1.3.1 Downstream Operation

An August 1983 agreement between DWR and DFG entitled, "Agreement Concerning the Operation of the Oroville Division of the State Water Project for Management of Fish & Wildlife," sets criteria and objectives for flow and temperatures in the LFC and the reach of the Feather River between Thermalito Afterbay and Verona. This agreement: (1) establishes minimum flows between Thermalito Afterbay Outlet and Verona which vary by water year type; (2) requires flow changes under 2,500 cfs to be reduced by no more than 200 cfs during any 24-hour period, except for flood management, failures, etc.; (3) requires flow stability during the peak of the fall-run Chinook spawning season; and (4) sets an objective of suitable temperature conditions during the fall months for salmon and during the later spring/summer for shad and striped bass.

1.3.1.1 Instream Flow Requirements

The Oroville Facilities are operated to meet minimum flows in the Lower Feather River as established by the 1983 agreement (see above). The agreement specifies that Oroville Facilities release a minimum of 600 cfs into the Feather River from the Thermalito Diversion Dam for fisheries purposes. This is the total volume of flows from the diversion dam outlet, diversion dam power plant, and the Feather River Fish Hatchery pipeline.

Generally, the instream flow requirements below Thermalito Afterbay are 1,700 cfs from October through March, and 1,000 cfs from April through September. However, if runoff for the previous April through July period is less than 1,942,000 af (i.e., the 1911-1960 mean unimpaired runoff near Oroville), the minimum flow can be reduced to 1,200 cfs from October to February, and 1,000 cfs for March. A maximum flow of 2,500 cfs is maintained from October 15 through November 30 to prevent spawning in overbank areas that might become de-watered.

1.3.1.2 Water Temperature Requirements

The Diversion Pool provides the water supply for the Feather River Fish Hatchery. The hatchery objectives are 52°F for September, 51°F for October and November, 55°F for December through March, 51°F for April through May 15, 55°F for last half of May, 56°F for June 1-15, 60°F for June 16 through August 15, and 58°F for August 16-31. A temperature range of plus or minus 4°F is allowed for objectives, April through November.

There are several temperature objectives for the Feather River downstream of the Afterbay Outlet. During the fall months, after September 15, the temperatures must be suitable for fall-run Chinook. From May through August, they must be suitable for shad, striped bass, and other warmwater fish.

NOAA Fisheries has also established an explicit criterion for steelhead trout and spring-run Chinook salmon. Memorialized in a biological opinion on the effects of the Central Valley Project and SWP on Central Valley spring-run Chinook and steelhead as a reasonable and prudent measure; DWR is required to control water temperature at Feather River mile 61.6 (Robinson's Riffle in the low-flow channel) from June 1 through September 30. This measure requires water temperatures less than or equal to 65°F on a daily average. The requirement is not intended to preclude pump-back operations at the Oroville Facilities needed to assist the State of California with supplying energy during periods when the California ISO anticipates a Stage 2 or higher alert.

The hatchery and river water temperature objectives sometimes conflict with temperatures desired by agricultural diverters. Under existing agreements, DWR provides water for the Feather River Service Area (FRSA) contractors. The contractors claim a need for warmer water during spring and summer for rice germination and growth (i.e., 65°F from approximately April through mid May, and 59°F during the remainder of the growing season). There is no obligation for DWR to meet the rice water temperature goals. However, to the extent practical, DWR does use its operational flexibility to accommodate the FRSA contractor's temperature goals.

1.3.1.3 Water Diversions

Monthly irrigation diversions of up to 190,000 (July 2002) af are made from the Thermalito Complex during the May through August irrigation season. Total annual entitlement of the Butte and Sutter County agricultural users is approximately 1 maf. After meeting these local demands, flows into the lower Feather River continue into the Sacramento River and into the Sacramento-San Joaquin Delta. In the northwestern portion of the Delta, water is pumped into the North Bay Aqueduct. In the south Delta, water is diverted into Clifton Court Forebay where the water is stored until it is pumped into the California Aqueduct.

1.3.1.4 Water Quality

Flows through the Delta are maintained to meet Bay-Delta water quality standards arising from DWR's water rights permits. These standards are designed to meet several water quality objectives such as salinity, Delta outflow, river flows, and export limits. The purpose of these objectives is to attain the highest water quality, which is reasonable, considering all demands being made on the Bay-Delta waters. In particular, they protect a wide range of fish and wildlife including Chinook salmon, Delta smelt, striped bass, and the habitat of estuarine-dependent species.

1.3.2 Flood Management

The Oroville Facilities are an integral component of the flood management system for the Sacramento Valley. During the wintertime, the Oroville Facilities are operated under flood control requirements specified by the U.S. Army Corps of Engineers (USACE). Under these requirements, Lake Oroville is operated to maintain up to 750,000 af of storage space to allow for the capture of significant inflows. Flood control releases are based on the release schedule in the flood control diagram or the emergency spillway release diagram prepared by the USACE, whichever requires the greater release. Decisions regarding such releases are made in consultation with the USACE.

The flood control requirements are designed for multiple use of reservoir space. During times when flood management space is not required to accomplish flood management objectives, the reservoir space can be used for storing water. From October through March, the maximum allowable storage limit (point at which specific flood release would have to be made) varies from about 2.8 to 3.2 maf to ensure adequate space in Lake Oroville to handle flood flows. The actual encroachment demarcation is based on a wetness index, computed from accumulated basin precipitation. This allows higher levels in the reservoir when the prevailing hydrology is dry while maintaining adequate flood protection. When the wetness index is high in the basin (i.e., wetness in the watershed above Lake Oroville), the flood management space required is at its greatest amount to provide the necessary flood protection. From April through June, the maximum allowable storage limit is increased as the flooding potential decreases, which allows capture of the higher spring flows for use later in the year. During September, the maximum allowable storage decreases again to prepare for the next flood season. During flood events, actual storage may encroach into the flood reservation zone to prevent or minimize downstream flooding along the Feather River.

2.0 NEED FOR STUDY

Task 3 is a subtask of SP-F21, *Project Effects on Predation of Feather River Juvenile Anadromous Salmonids*. Task 3 fulfills a portion of the FERC application requirements by identifying and characterizing the potential effects of project operations and associated artificial structures on the level of predation on ESA listed anadromous salmonids. In addition to fulfilling statutory requirements, information collected during this task may be used in developing or evaluating potential Resource Actions.

Ongoing operation of the Oroville Facilities has the potential to influence potential predator interactions with juvenile anadromous salmonids by altering in-river conditions from those that occurred historically. SP-F21 examines project effects on predation of juvenile anadromous salmonids in the Feather River. Task 3, herein, summarizes the existing literature on predation of juvenile anadromous salmonids associated with project operations and artificial structures from other basins with similar characteristics and determines their applicability to the Feather River. Task 1 describes the life history and habitat requirements of predator and prey species of primary management concern. Task 2 summarizes existing data describing distribution of predator and prey species of primary management concern in the Feather River. Task 4 summarizes and reports potential Resource Actions that are designed to reduce predation occurring at artificial structures, or resulting from hydropower operations, and evaluate their potential applicability to the Oroville Facilities operations. For further description of Tasks 1, 2 or 4, see SP-F21 and associated interim and final reports.

3.0 STUDY OBJECTIVE(S)

The objective of SP-F21 Task 3 is to identify and categorize the potential effects of project operations and associated artificial structures on the predation of juvenile anadromous salmonids within the study area.

3.1 APPLICATION OF STUDY INFORMATION

The purpose of SP-F21 Task 3 is to identify and characterize the potential effects of project operations and associated artificial structures on the predation of juvenile anadromous salmonids within the study area. Data collected in this task also serve as a foundation for future evaluations and development of potential Resource Actions. Information obtained in this study is associated with, and will be applied to, the following purposes and activities:

3.1.1 Department of Water Resources/Stakeholders

The information from this analysis will be used by DWR and the Environmental Work Group (EWG) to evaluate the effects of artificial structures and project operations on project anadromous salmonid fisheries. Additionally, data collected in this task serves as a foundation for future evaluations and development of potential Resource Actions.

3.1.4 Environmental Documentation

In addition to Section 4.51(f)(3) of 18 CFR, which requires reporting of certain types of information in the FERC application for license of major hydropower projects (FERC 2001), it may be necessary to satisfy the requirements of the National Environmental Policy Act (NEPA) as well as the ESA. Because FERC has the authority to grant an operating license to DWR for continued operation of the Oroville Facilities, discussion is required to identify the potential impacts of the project on many types of resources, including fish, wildlife and botanical resources. In addition, NEPA requires discussion of any anticipated continuing impact from on-going and future operations. To satisfy NEPA and ESA DWR is preparing a Preliminary Draft Environmental Assessment (PDEA) to attach to the FERC license application, which shall include information provided by this study plan report.

3.1.5 Settlement Agreement

In addition to statutory and regulatory requirements, SP-F21 Task 3 provides information, which may be useful in the development of potential Resource Actions, to be negotiated during the collaborative process. Additionally, information obtained from this analysis of the project effects on predation of juvenile anadromous salmonids could be used during the collaborative settlement process.

4.0 METHODOLOGY

4.1 STUDY DESIGN

Although many predatory species are native to the Feather River, in-river artificial structures and project operations may have altered normal predator-prey interactions. Additionally, non-native predatory species have been introduced into the lower Feather River and project effects may have enhanced their predatory interactions with juvenile anadromous salmonids. Physical changes to the habitat including alterations caused by artificial structures, flow and water temperature regimes, and migration barriers are evaluated in the context of predator-prey interactions. Additionally, each identified predator species is discussed as to potential impact on juvenile anadromous salmonids.

4.2 HOW AND WHERE STUDIES WERE CONDUCTED

A literature review was conducted to investigate the potential for predation on juvenile anadromous salmonids associated with artificial structures and project operations in the lower Feather River. Local and regional studies on predation were evaluated and used when applicable to the Feather River, and were supplemented with studies from other basins with similar predator and prey species compositions. The applicability of the literature review results to the Feather River system was assessed by comparing the habitat types, artificial structures, hydraulics associated with those structures, operational patterns, seasonal flow fluctuations, water temperatures, and ecosystem structure evaluated in the literature to the Feather River and Oroville Facilities.

Potential predatory species in the study area were partially identified in SP-F3.2 Task 1 and SP-F10. Non-anadromous salmonids known to be present in the study area were also considered as potential predators. Each of these potential predators is discussed separately. Because only limited data exist on abundance and distribution of predator and prey species in the study area at any point in time, this report provides a conceptual, qualitative evaluation of effects of operations on predation through review of existing literature.

Predation has been suggested to be the principal cause of mortality among fry and fingerling Chinook salmon (Healey 1991). Therefore, an analysis of CWT return data was conducted to determine the extent of predation on Feather River juvenile Chinook salmon. CWT analysis typically is used to measure survival of salmon from time of tagging to hatchery return or ocean harvest. Comparing survival rates of juvenile Chinook released in the Feather River with the survival of juveniles released in San Pablo Bay should provide a measure of juvenile out-migration survival assuming that survival following salt water entry would be similar for both groups. Although factors other than predation may contribute to out-migration survival, it is assumed that a substantial portion of out-migrant anadromous salmonid mortality is a result of predation.

5.0 STUDY RESULTS

5.1 PHYSICAL ALTERATIONS TO HABITAT

Construction and operation of the Oroville Facilities has divided the reach of the Feather River extending downstream from Lake Oroville to the Sacramento River into two distinct segments. The upstream segment extends from the Fish Barrier Dam at river mile (RM) 67.3 to the Thermalito Afterbay Outlet at RM 59 and is referred to as the LFC (Figure 5.1-1). An almost constant, year-round flow regime and relatively cool water temperatures characterize the LFC.

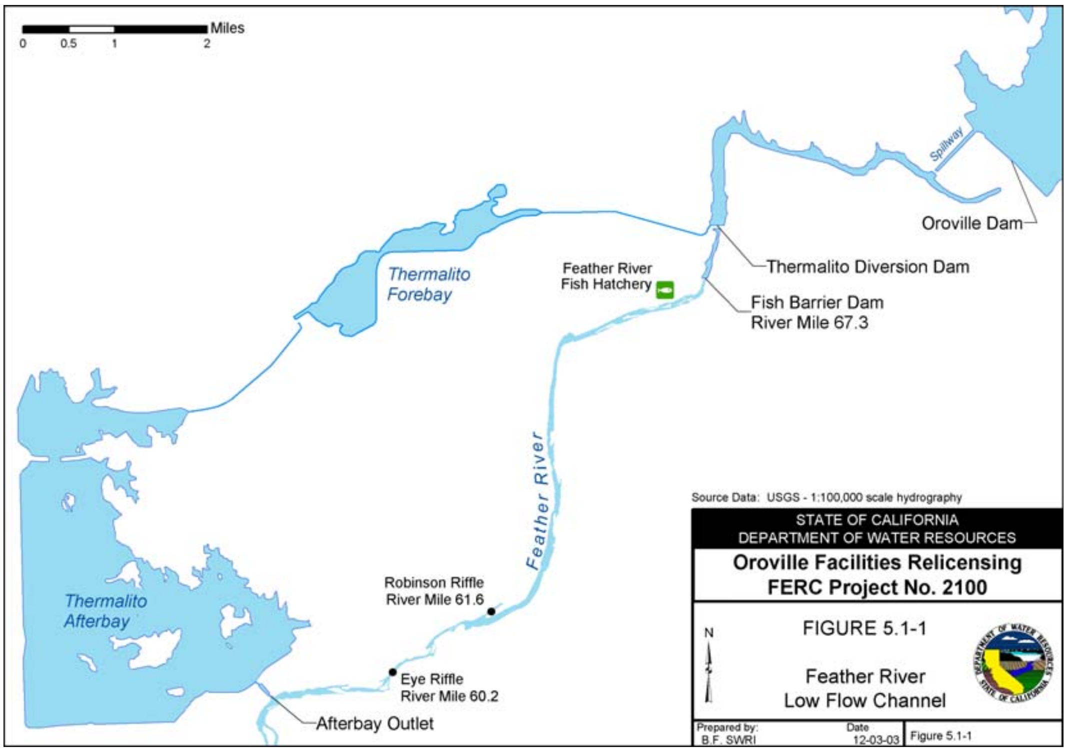

Figure 5.1-1. Feather River Low Flow Channel.

The river segment extending from the Thermalito Afterbay Outlet to the confluence with the Sacramento River (a distance of 59 miles) is referred to as the High Flow Channel (HFC) (Figure 5.1-2) and is characterized by having a more variable flow regime and warmer water temperatures than those observed in the LFC.

Both of the reaches of the lower Feather River have a unique set of physical characteristics that are primarily determined by project structures and operations. Project structures may have a direct effect on habitat because they are directly associated with the river, while project operations could directly and indirectly affect habitat availability and are not necessarily located immediately adjacent to the Feather River. Because physical habitat characteristics such as water temperatures in each reach are different, a dissimilar suite of predator and prey species may inhabit each reach.

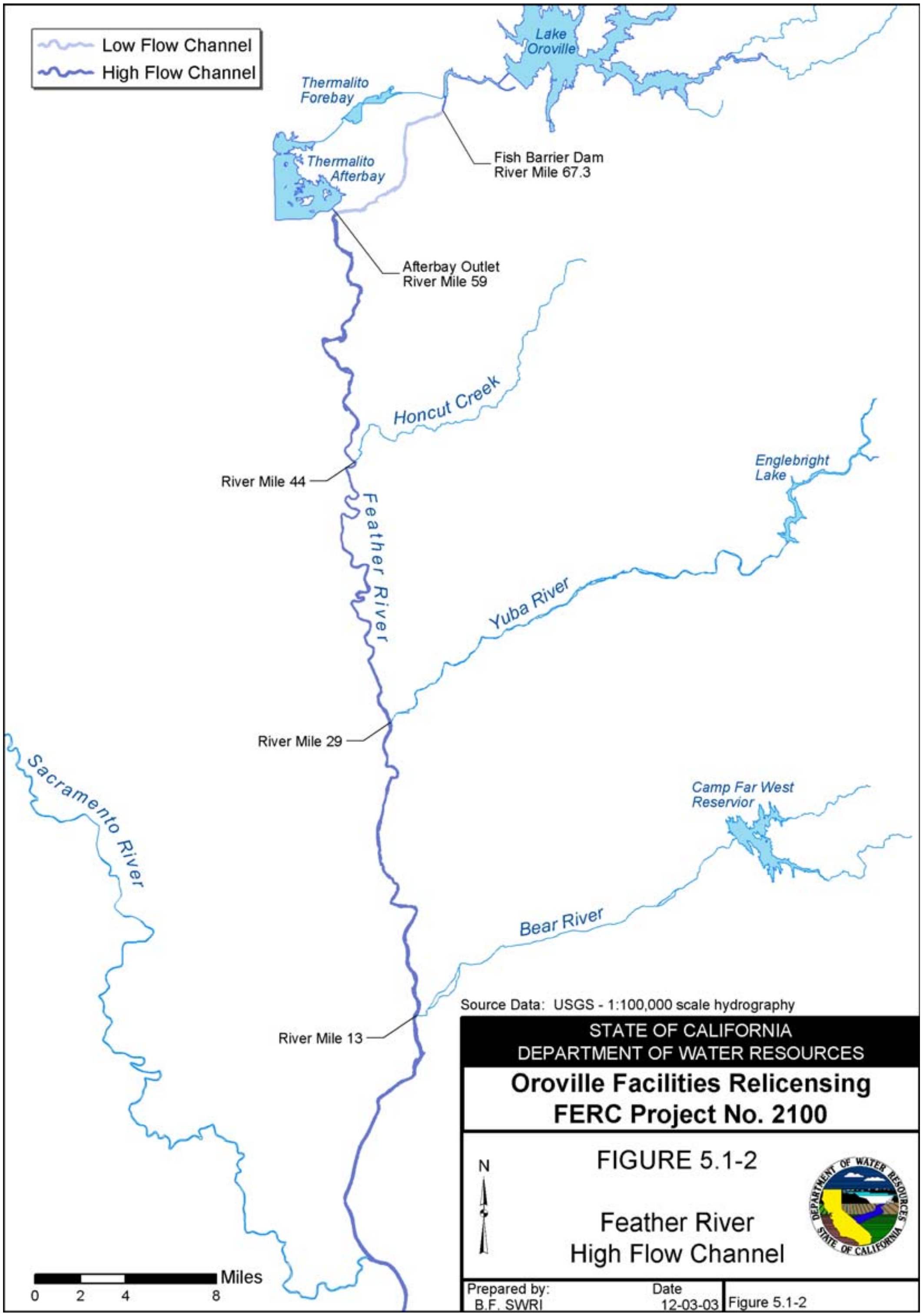

Figure 5.1-2. Feather River High Flow Channel.

5.1.1 Project Structures and Operations

Project structures in the area that have a direct effect on riverine habitat in the lower Feather River include the Fish Barrier Dam and the Thermalito Afterbay Outlet. Project operations affecting riverine habitat include operation of the Oroville Dam, the FRFH, the Thermalito Diversion Dam, and the Thermalito Afterbay Dam.

5.1.1.1 Fish Barrier Dam

The purpose of the Fish Barrier Dam is to divert upmigrating anadromous salmonids into a fish ladder leading to the FRFH and to act as a barrier preventing further upstream migration of anadromous salmonids (DWR 2001). Because the Fish Barrier Dam prohibits further upstream migration, anadromous salmonids are artificially concentrated in the area below the dam. Additionally, the pool formed at the base of the dam could potentially create hydraulic conditions that favor predators. For example, Faler et al. (1988) reported increased predation activity by northern pikeminnow (*Ptychocheilus oregonensis*) in pool environments. Additionally, several authors reported high concentrations of pikeminnow associated with pools formed below dams (Beamesderfer 2000; Gray and Rondorf 1986; Poe 1992). Pikeminnow, however, are less frequently observed in the LFC than the HFC (pers. com., B. Cavallo, DWR, 2004).

Another effect of blocking upstream migration has been the elimination of the spatial separation between fall and spring-run Chinook salmon spawning. Reportedly, spring-run Chinook salmon historically migrated to the upper Feather River and it's tributaries from mid-march through the end of July (DFG 1998). Fall-run Chinook salmon reportedly migrated later and spawned in lower reaches than spring-run Chinook salmon (Yoshiyama et al. 2001). Because spring-run Chinook salmon currently are forced to spawn in the lower reaches of the Feather River, juveniles may be exposed to a different suite of predators than those to which they were historically exposed. Consequently, because the suite of predators to which spring-run Chinook salmon currently are exposed may be different than that to which they were historically exposed, adaptation to the current predator suite could potentially be occurring.

5.1.1.2 Thermalito Afterbay Outlet

The plunge pool created by the outfall from the Thermalito Afterbay Outlet also may provide additional habitat for predators. Spills from the Thermalito Afterbay outlet may create back-roll, or standing wave patterns, at certain spill levels, which reportedly can trap juvenile fish in turbulence, adding to the potential for predation (Whitney et al. 1997), although others report reduced predation by northern pikeminnow on juvenile salmonids in turbulent conditions (Faler et al. 1988). Both largemouth bass and Sacramento pikeminnow frequently are observed near the Thermalito Afterbay outlet (DWR 2003).

5.1.1.3 Oroville Dam and Feather River Fish Hatchery

Water temperature regimes in the LFC are driven by FRFH objectives described in an agreement between DWR and DFG that was signed in 1983 (DWR 1983; DWR 2001). Hatchery water temperature objectives are depicted in Table 5.1-1. A water temperature range of plus or minus 4°F is allowed for objectives, from April through November (DWR 1983). Meeting these water temperature objectives is facilitated by a shutter controlled intake gate system at the Oroville Dam that selects water for release from different reservoir depths (DWR 2001). Compared to historic water temperatures, mean monthly water temperatures reportedly are between 2°F and 14°F cooler from May through October, and between 2°F and 7°F warmer from November through April (DWR and USBR 2001).

Table 5.1-1. Feather River Fish Hatchery water temperature objectives.

Period	Temperature (ºF)
April 1 - May 15	51º
May 16 – May 31	55º
June 1 - June 15	56º
June 16 – August 15	60º
August 16 – August 31	58º
September 1 – September 30	52º
October 1 – November 30	51º
December 1 – March 31	55º

Source. (DWR 1983; DWR 2001)

Water temperatures in the lower Feather River were collected by DWR from March 26, 2002 through April 17, 2003. Maximum, minimum and mean water temperature data were recorded on a daily basis from 24 different monitoring locations in the lower Feather River. In certain instances, water temperature data were missing and/or sample dates were inconsistent as a result of dewatered logging stations, vandalism, or equipment malfunction. Figure 5.1-3 shows recorded water temperatures from three locations in the LFC along with hatchery water temperature objectives.

In addition to providing a mechanism for controlling water temperature in the LFC, Oroville Dam in conjunction with other dams has blocked the transport of sand and gravel from the upstream reaches of the watershed. Currently, only very fine sediment is transported to the downstream reaches of the Feather River. The dams block all of the gravel and most of the sand resulting in loss of gravel recruitment to salmon spawning riffles in the downstream reaches (DWR 2001). The lack of gravel recruitment potentially has caused some riffles to become armored by cobbles and boulders, limiting spawning habitat. Additionally, the same lack of gravel recruitment may have limited rearing areas for juvenile salmonids and created artificially high concentrations of juveniles in remaining favorable habitat. The artificially high concentrations of juveniles in some areas could potentially enhance predation opportunities.

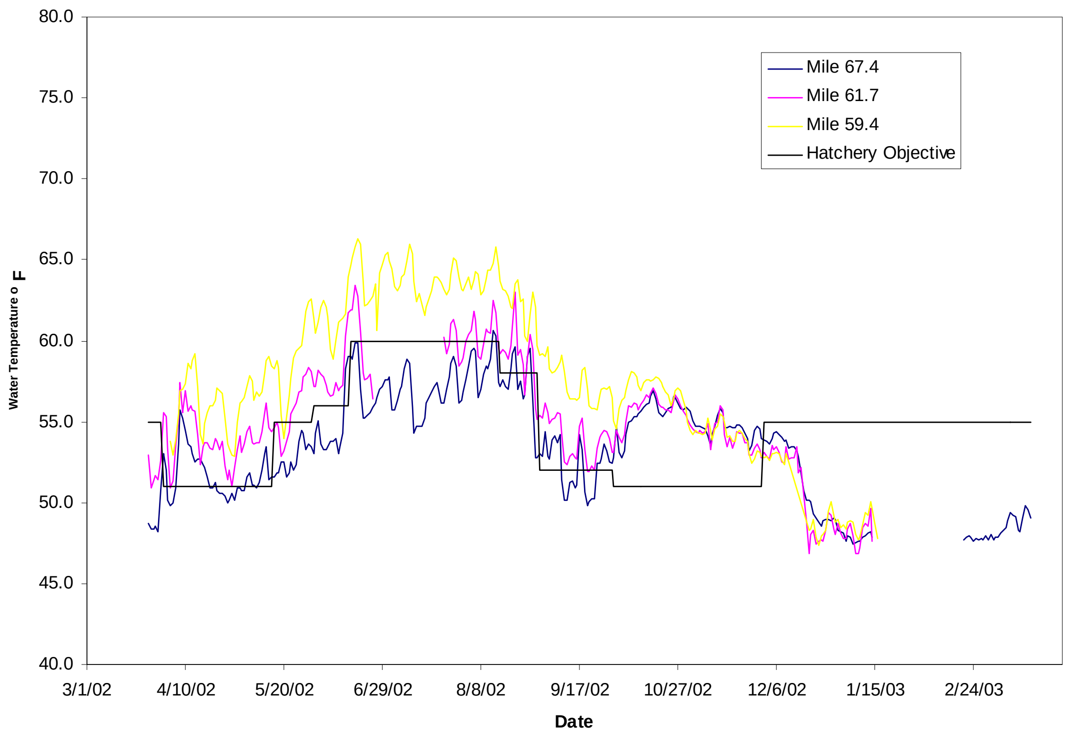

Figure 5.1-3. Representative Low Flow Channel Water Temperatures and Hatchery Water Temperature Objectives (2002-2003).

The FRFH, in addition to driving water temperature objectives in the LFC, raises juvenile steelhead to yearling age and then releases them at various locations in the Feather River. Release practices could potentially result in un-naturally crowding fish at the time they are released providing a potentially high concentration of prey for predators of anadromous salmonids in the lower Feather River. Significant increases in pikeminnow populations at specific sites following hatchery releases of juvenile salmonids have been documented (Collis et al. 1995). Additionally, yearling steelhead are piscivores and a potential predator on juvenile Chinook salmon and young-of-year naturally spawned steelhead rearing in the Feather River. Juvenile Chinook salmon also are released into different locations of the HFC (Kastner 2003). Evanson et al. (1981) *in* Fresh (1997) reported that the average annual loss of wild Chinook salmon and steelhead over a three year period due to predation by hatchery fish was 9.7 percent in the Rogue River, Oregon. Martin et al. (1993) *in* Fresh (1997) reported that 95 percent of juvenile Chinook salmon were preyed on in the Tucannon River, Washington within 4.5 months following a release of juvenile steelhead.

5.1.1.4 Thermalito Diversion Dam

The Thermalito Diversion Dam is located approximately four miles downstream from Lake Oroville. The dam diverts water from the Feather River into the Thermalito Power Canal for transport to the Thermalito Pumping-Generating Plant. The diversion dam also maintains a constant flow of 600 cfs into the LFC. Several authors suggest that regulated flow regimes enhance the ability of non-native fish to colonize new areas (Marchetti and Moyle 2001; Moyle and Light 1996). By contrast, however, Seesholtz et al. (2003) suggest that the LFC, with a moderate base flow regime and relatively cool water temperatures, may provide a competitive advantage to native fish.

5.1.1.5 Thermalito Afterbay Dam

The Thermalito Afterbay Dam releases water to the Thermalito Afterbay Outlet, which defines the downstream extent of the LFC and the upstream extent of the HFC of the lower Feather River. Water temperatures in the upper portion of the HFC are directly influenced by releases from the Thermalito Afterbay Outlet. Because the Thermalito Afterbay is a large, shallow reservoir, water released from the dam is typically warmer than the water originating from the LFC. The effects of Thermalito Afterbay releases can potentially be significant and result in substantial increases in water temperatures in the HFC (DWR and USBR 2001). Water temperatures recorded at representative locations in the HFC are depicted in Figure 5.1-4.

Figure 5.1-4. Representative High Flow Channel Water Temperatures, 2002–2003.

The Thermalito Afterbay Outlet also is a major contributor to the flow regime in the HFC. Unlike the constant flow regime in the LFC, flows in the HFC vary depending on the month and amount of runoff from upstream. Minimum flow requirements in the HFC also were determined by the agreement signed by DWR and DFG in 1983, and range from 1,000 to 1,700 cfs depending upon the month and the amount of runoff (DWR 1983). Normal Feather River flows usually are above the minimum requirements (Figure 5.1-5).

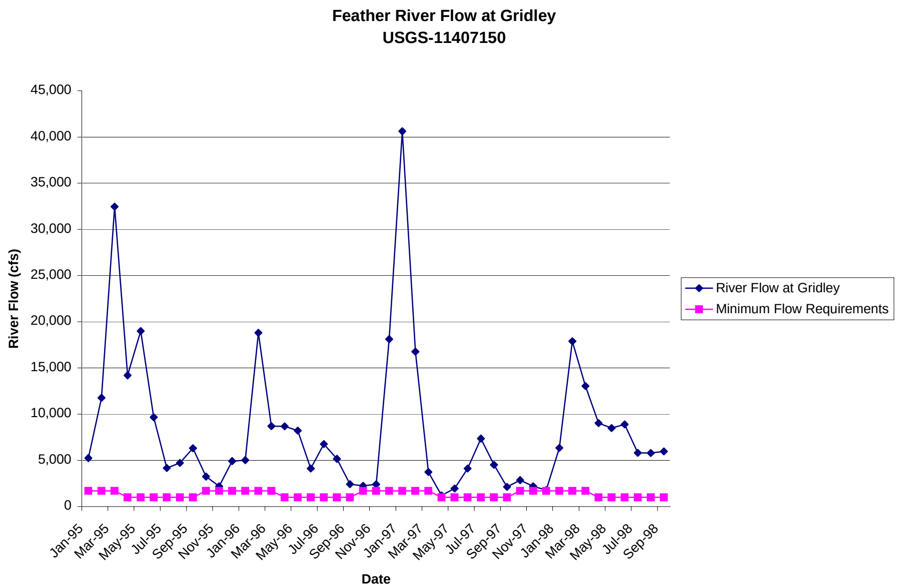

Figure 5.1-5. Feather River Flow data recorded at Gridley from January 1995 through September 1998.

5.2 PREDATORY SPECIES

Potential predators on juvenile anadromous salmonids that have been documented in the Feather River are listed in table 5.2-1.

Table 5.2-1. Potential predatory fish in lower Feather River.

Species	Common Name	Comments
Ptychocheilus grandis	Sacramento Pikeminnow	Native
Morone saxatilis	Striped Bass	Non-native
Oncorhynchus mykiss	Steelhead/Rainbow Trout	Native/Non-native
Micropterus salmoides	Largemouth Bass	Non-native
Micropterus dolomieu	Smallmouth Bass	Non-native

Source. (DWR 2001), (DWR 2003)

5.2.1 Sacramento Pikeminnow

Most predation studies involving pikeminnow and juvenile salmonids have been associated with dam bypass systems, particularly in the Columbia River system where artificially high concentrations of juvenile out-migrant salmonids reportedly are concentrated near passage structures (Beamesderfer et al. 1990; Beamesderfer and Rieman 1991; Bennett 1998; Brown and Moyle 1981; Buchanan et al. 1981; Gray and Rondorf 1986; Normandeau Associates 2001). Because the Oroville Facilities do not currently provide juvenile fish passage facilities, the applicability of these studies to the

Oroville project is limited. There are, however, some similarities between the systems. For example, both systems have unusually high concentrations of juvenile salmonids in some areas due to facility operations. The release of both juvenile Chinook salmon and steelhead from the Feather River Hatchery creates somewhat similar conditions to a juvenile fish bypass system.

The Sacramento pikeminnow (*Ptychocheilus grandis*) reportedly is the third most common species of native fishes in the lower Feather River (Seesholtz et al. 2003). Although a different species, northern pikeminnow reportedly are major predators of juvenile salmonids in the Columbia River system (Bennett 1998; Normandeau Associates 2001; Poe et al. 1991). Bennett (1998) reported up to 78% of losses associated with predation in the Snake River of Idaho were due to pikeminnow predation. A study performed by Normandeau Associates (2001) indicated that approximately 67% of the diet of pikeminnow during smolt out-migration in the Columbia River is made up of juvenile salmonids. Chinook salmon reportedly were favored over steelhead during the study. Additional results reported by Normandeau Associates indicated that pikeminnow predation on salmonids increased significantly when water temperatures rose above 63^{o}F. Friesen (1999) reported that most predation of juvenile salmonids by pikeminnow occurs in pool areas and that pikeminnow are not significant predators in faster moving water. Friesen (1999) and Petersen (1990) both reported pikeminnow consumption rates to be very low when water temperatures fell below 60^{o}F. Based on the results of studies on pikeminnow predation in the Columbia River, 60^{o}F and 63^{o}F were used as index values against which pikeminnow predation potential in the Feather River could be evaluated.

Seesholtz et al. (2003) reported that most out-migration of juvenile Chinook salmon occurs in the Feather River between January and April. Water temperature regimes in the LFC during that time period are below those at which pikeminnow begin actively feeding, while water temperatures favorable to pikeminnow occur after the majority of juvenile Chinook salmon have emigrated from the area (Figure 5.2-1).

Water temperatures in the HFC, from the Thermalito Afterbay Outlet downstream to the confluence with the Yuba River, appear to be more favorable to pikeminnow than those in the LFC. Water temperatures in this area tend to favor pikeminnow predation from early April through early October (Figure 5.2-2). That is, water temperatures in the reach are above 60^{o}F most of the time. Although HFC water temperatures are still below favored pikeminnow feeding values during the peak of the juvenile Chinook out-migration, based on the relative abundance of pikeminnow in the HFC compared to the LFC (pers. com., B. Cavallo, 2004), it is expected that some predation on juvenile salmonids would occur.

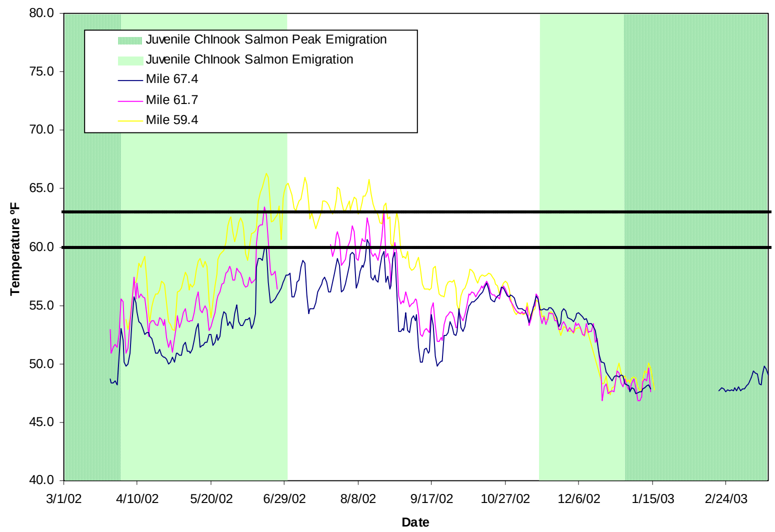

Figure 5.2-1. Water temperatures at three locations in the Low Flow Channel during 2002, pikeminnow predation water temperature indices, and the juvenile Chinook salmon emigration period.
Note: Mile 67.4 – Fish Barrier Dam; Mile 61.7 – Robinson Riffle; Mile 59.4 – upstream from Afterbay Outlet.[1]

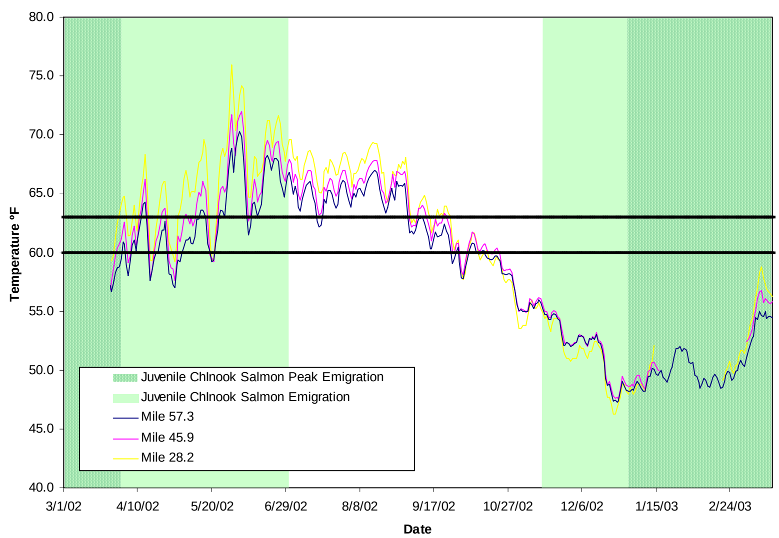

Figure 5.2-2. Water temperatures at three locations in the High Flow Channel during 2002, pikeminnow predation water temperature indices, and the juvenile Chinook salmon emigration period.
Note: Mile 57.3 – Downstream from Afterbay Outlet; Mile 45.9 – Upstream from Honcut Creek confluence; Mile 28.2 – Downstream from Yuba River confluence.[1]

[1] [a]Significant increase in predation of Chinook salmon by pikeminnow when water temperatures exceed 63ºF (Friesen and Ward 1999).
[b]Pikeminnow prey consumption rates very low with water temperatures below 60ºF (Friesen and Ward 1999; Petersen et al. 1990).

Seesholtz et al. (2003) captured fish in both the LFC and HFC from January through August in 1999, 2000, and 2001. Sampling efforts were conducted utilizing both rotary screw trap and seining techniques. During the study period, 91 to 97 percent of the total juvenile Chinook salmon catch occurred during January, February and March. Analysis of available water temperature data indicates that from January through March 2002, water temperatures in the LFC and HFC are below pikeminnow predation index values. Because water temperature data were not available during the same years in which the outmigrant studies were performed, direct comparisons could not be made. It was assumed, however, that because the water temperatures in 2002 were substantially lower than 60°F during the reported Chinook salmon outmigration period, and because the majority of juvenile Chinook salmon emigrate during the winter months when water temperatures are relatively low, that the water temperatures during the peak Chinook salmon emigration period likely are below 60°F during most years. Therefore, during the peak Chinook salmon emigration period, pikeminnow predation likely is low.

5.2.2 Striped Bass

Striped bass (*Morone saxatilis*) are an introduced game fish species in the Sacramento River system that has been documented in the lower Feather River (DWR 2001). Striped bass reportedly have been shown to be significant predators on juvenile Chinook salmon (DWR 1995; Johnson et al. 1992). Some reports suggest that increasing striped bass populations in the Sacramento River could lead to the extinction of winter-run Chinook salmon in the area (Lindley and Mohr 1998), and Axon and Whitehurst (1985) describe predation on salmonids as a major concern in areas where striped bass have been introduced. In areas near the Sacramento River Delta, salmonids, particularly juvenile Chinook salmon, reportedly can compose from 60 percent to 95 percent of the diet of striped bass (DWR 1995). A predation model developed for the Coos River, Oregon by Johnson et al. (1992) estimated that striped bass in the system would consume between 42,000 and 383,000 juvenile salmonids per year (Johnson et al *in* Fresh 1997). Striped bass reportedly prefer a water temperature range of 68°F to 75.2°F (Emmett et al. 1991). These water temperatures occur only in the HFC from the end of May through August. Stevens et al. (1985) reported juvenile Chinook salmon being preyed on by striped bass during the spring and summer months in the Sacramento River. Water temperatures between 68°F and 75.2°F occur in the HFC from the end of May through August, which is outside the reported peak emigration period for juvenile Chinook salmon in the lower Feather River.

5.2.3 Steelhead/rainbow trout

Steelhead reportedly are native to the Feather River (DWR 2001). Non-anadromous rainbow trout also have been stocked in tributaries of the lower Feather River, and the FRFH regularly releases yearling steelhead into the Feather River (DWR 2001). Both rainbow trout and hatchery reared yearling steelhead are potential predators of juvenile Chinook salmon and young-of-year naturally spawned steelhead. Seesholtz et al. (2003) reported that 90 percent of juvenile steelhead rearing in the LFC, with 78 percent of those juveniles found in the upper 1.24 miles (2 km) of the reach near the Fish Barrier Dam.

5.2.4 Largemouth Bass

Largemouth bass (*Micropterus salmoides*) are an introduced warmwater species found in the Feather River (DWR 2001). Largemouth bass over 7.9 inches (200 mm) in length reportedly prey heavily on juvenile salmonids (Shrader and Moody 1998). However, Shrader and Mooney (1998) reported that salmonids only became a significant portion of largemouth bass diets during June and July. Moyle (2002) has reported that when given a choice, largemouth bass prefer water temperatures above 27.0^{o}C (80.6^{o}F), which is above most recorded water temperatures in the lower Feather River. Of 29 species of fish captured in the Lower Feather River, Seesholtz et al. (2003) reported that largemouth bass ranked 14th in abundance. Largemouth bass reportedly are the most common of the black bass species observed in the lower Feather River (DWR 2003).

5.2.5 Smallmouth bass

Smallmouth bass (*Micropterus dolomieu*) are an introduced warmwater species, whose presence has been documented in the lower Feather River (DWR 2001). Smallmouth bass reportedly are known to be a significant predator on juvenile salmonids in Lake Washington, Washington (Fayram and Sibley 2000). Bennett (1998) reported that smallmouth bass were the most significant non-native predator of juvenile salmonids in the Snake River system, Idaho. By contrast, Poe et al. (1991) suggest that smallmouth bass were not important predators of juvenile salmonids in the John Day Reservoir on the Columbia River. Loomis (1998) stated that smallmouth bass do not become significant predators until water temperatures exceed 60^{o}F. When temperatures exceed 70^{o}F, smallmouth bass reportedly consume more juvenile salmonids than pikeminnow when both species inhabit the same system (Tabor et al. 1993). Based on the water temperatures reported in the literature at which smallmouth bass predation increases, it appears that smallmouth bass predation of juvenile salmonids would occur at similar times of year as pikeminnow predation of juvenile salmonids. Seesholtz et al. (2003) found smallmouth bass to be relatively scarce in the Feather River, and only found the species in the HFC.

5.3 CODED WIRE TAG RECOVERY ANALYSIS

Cramer and Chapman (2002) performed a coded wire tag recovery analysis on five selected brood years of Chinook salmon hatched, reared, and tagged at the FRFH. Survival of Chinook salmon released in the estuary, the Sacramento River, and the Feather River was compared for fish returning at age two. The results of the study indicate a 7.2 percent survival rate for fish released in the estuary, a 4.0 percent survival rate for fish released in the Sacramento River, and a 3.5 percent survival rate for fish released in the Feather River. Similar results were obtained in the study of four different brood years of Chinook salmon tagged at the Coleman National Fish Hatchery (Cramer and Chapman 2002). Cramer and Chapman (2002) concluded that survival increased as in-river emigration distance decreased.

The Regional Mark Information System (RMIS) Species Survival Analysis database reporting system of the Pacific States Marine Fisheries Commission (PSMFC) was used to analyze survival rates of Chinook salmon brood years 1996 and 1997 from the FRFH. Survival was defined as the survival from the time of tagging to coded wire tag recovery from returning fish to the hatchery, or the commercial or sport ocean harvest. Because it was assumed that the released fish faced similar ocean conditions regardless of their release location, differences in survival could be due to in-river emigration mortality, a significant portion of which could be due to predation. Results of this analysis are depicted in Table 5.3-1.

Table 5.3-1. Survival of Feather River Fish Hatchery hatched and reared Chinook salmon.

Brood Year	Release Location	Survival %
1996	Port Chicago (estuary)	1.26
1996	Sacramento River at Miller Park	0.85
1996	Feather River	0.73
1997	Carquinez Strait (estuary)	1.28
1997	Sacramento River at Verona	0.88
1997	Feather River at Gridley	0.67

Source: PSMFC RMIS database accessed December 2003.

Using the data collected from the RMIS database to compute an in-river emigration survival rate for juvenile Chinook salmon hatched and reared at the FRFH, and released in the Feather River, yielded a survival rate of 0.67 percent and 0.73 percent in 1996 and 1997, respectively. Juvenile Chinook salmon released in the Sacramento River displayed a survival rate of 0.85 percent in 1996 and 0.88 percent in 1997. The survival rate of juvenile Chinook salmon from the Sacramento River at Verona to the Carquinez Strait in 1997 was 69 percent. Although small sample size precludes statistical analysis, these results suggest that mortality in the Feather River is comparable to other downstream locations, particularly those in the Sacramento River. However, multiple confounding variables such as differences in river size, water temperature regime, and migration distance render the comparison between mortality rates in the Sacramento and Feather rivers difficult using the available data.

6.0 ANALYSES

6.1 EXISTING CONDITIONS/ENVIRONMENTAL SETTING

Task 3 is a subtask of SP-F21, *Project Effects on Predation of Feather River Juvenile Anadromous Salmonids*, and fulfills a portion of the FERC application requirements by identifying and characterizing the potential effects of project operations and associated artificial structures on the level of predation on ESA listed anadromous salmonids.

A literature review was conducted to investigate the potential for predation on juvenile anadromous salmonids associated with artificial structures and project operations in river basins other than the Feather River. The results of analysis of those studies were applied to the lower Feather River when applicable. Local and regional studies on predation were evaluated first and supplemented with studies from other basins with similar predator and prey species compositions. The applicability of the literature review results to the Feather River system was assessed by comparing the habitat types, artificial structures, hydraulics associated with those structures, operational patterns, seasonal flow fluctuations, water temperatures, and ecosystem structure evaluated in the literature to the Feather River and the Oroville Facilities.

In-river structures of concern in the area include the Fish Barrier Dam and its associated plunge pool and the plunge pool created by the Thermalito Afterbay Outlet. Project operations affect water temperature and flow regimes in the lower Feather River while operation of the Feather River Hatchery may create artificially high concentrations of juvenile Chinook salmon in the HFC and create high concentrations of steelhead in the LFC, which increases the amount of potential prey, but also may increase predation on rearing juvenile Chinook salmon in the LFC.

6.2 PROJECT RELATED EFFECTS

Predation has been suggested as the principal cause of mortality among fry and fingerling Chinook salmon (Healey 1991). An analysis of CWT data was conducted to attempt to determine the extent of predation on Feather River juvenile Chinook salmon. CWT analysis typically is used to measure survival of salmonids from the time that tagging took place until the tag was recovered, usually when the tagged adult returned to a hatchery, or was captured during ocean harvest. Comparing survival rates of juvenile Chinook salmon released in the Feather River with the survival rates of juveniles released in the Sacramento River could provide a measure of juvenile out-migration survival assuming that survival following salt water entry would be similar for both groups.

Although predation is a normal ecosystem function, there is a possibility that the Oroville project may disrupt normal predator-prey interactions and confer an advantage to predators in the project area. Within the available literature, most studies focusing on predation of juvenile anadromous salmonids associated with dams have been conducted on the Columbia River system. Additionally, most of the studies involved predation associated with fish passage facilities. Therefore, their applicability to the Feather River and the Oroville Facilities currently is limited. There are, however, some similarities between the Columbia River and Feather River systems. For example, both systems have altered in-river habitat, and similar suites of predators. Additionally, the Feather River system has an upstream migration barrier, which contributes to the artificially high concentrations of juvenile salmonids at certain times of the year, and potentially is similar to that which occurs at downstream juvenile salmonid passage facilities on the Columbia River.

The Fish Barrier Dam marks the upstream extent of anadromous salmonid spawning, and contributes to unusually high spawning concentrations in the LFC. The Thermalito Afterbay Outlet further concentrates spawning activity in the LFC because releases from the Thermalito Afterbay are warmer during some times of the year than those historically reported for the reach (DWR and USBR 2001). The high concentration of spawning salmonids in the LFC reportedly results in a high concentration of juvenile salmonids in the LFC (Seesholtz et al. 2003). Additionally, Seesholtz et al. (2003) found that most out-migration of juvenile Chinook salmon occurs between January and April and that these fish were relatively small. Based on historic accounts of juvenile salmonid emigration, the current peak in the emigration period is somewhat earlier than pre-dam conditions (Painter et al. 1977; Warner 1954). Seesholtz et al. (2003) further report that substantial numbers of juveniles remain in the LFC through the end of June. One hypothesis suggested as an explanation for the bimodal emigration period reported by Seesholtz et al (2003) is that competitive interactions between juvenile Chinook salmon force an earlier out-migration than that reported by Painter (1977) and Warner (1954) (DWR and USBR 2001). It is possible that those fish forced to emigrate from the LFC at an early age may be more susceptible to predation than those that remain in the LFC and migrate at a larger size.

Predators known to inhabit the LFC include yearling steelhead and Sacramento pikeminnow. Low water temperatures (seldom exceeding 60^{o}F) and fewer observations of pikeminnow in the LFC than the HFC (pers. com., B. Cavallo, 2004) likely indicate that pikeminnow predation on salmonids in the pool at the base of the Fish Barrier dam is low. Although little is known about steelhead predation on juvenile Chinook salmon, the release of hatchery steelhead after the peak Chinook salmon emigration period likely precludes significant predation on emigrating juvenile Chinook salmon. Predation on rearing juvenile Chinook salmon could occur, however.

The Thermalito Afterbay Outlet delineates the downstream extent of the LFC and the upstream extent of the HFC. The Thermalito Afterbay Outlet creates a plunge pool with relatively warm water that could favor warmwater predators during normal flows. Although no studies on predation have been conducted in the Thermalito Afterbay Outlet pool and surrounding areas, conditions appear appropriate for both pikeminnow and smallmouth bass during some times of year based on literature reviewed for the Columbia River system. During high flow events, the outlet could potentially form a standing wave pattern, which reportedly could trap juvenile salmonids in turbulence, making them vulnerable to predation (Whitney et al. 1997). However, water temperatures in this area are not conducive to active feeding by predators during the reported peak Chinook salmon migration period (Figure 5.2-1).

In addition to pikeminnow and steelhead in the LFC, predators known to occur in the HFC include resident rainbow trout, striped bass, largemouth bass and smallmouth bass, which are not native to the Feather River system (Seesholtz et al. 2003).

Striped bass, largemouth bass, and smallmouth bass all are considered warmwater fishes. Based on the 2002/2003 water temperature profile (Figure 5.2-2) these species likely are not actively feeding during the reported peak Chinook salmon migration period, although they would be active during some of the reported out-migration period, beginning in mid-April. Warmwater predator species also may feed on steelhead migrating later in the year.

CWT recovery analysis indicates that mortality of out-migrating juvenile Chinook salmon reared in the FRFH and released into the Feather River or Sacramento River may be high. However, comparing juvenile Chinook salmon released in the Feather River to those released in the Sacramento River suggests that mortality is not unusually high in the Feather River segment. However, multiple confounding variables such as differences in river size, water temperature regime, and migration distance between the Sacramento and Feather rivers makes interpretation of the differences in survival rates between juvenile Chinook salmon released at different locations difficult.

Recent studies have shown high numbers of juvenile Chinook salmon emigrating from the lower Feather River (Seesholtz et al. 2003). At the same time, high spawning escapements, equivalent to pre-dam years, reportedly have been observed (Yoshiyama et al. 2000). Additionally, a review of available literature indicates that environmental conditions in the lower Feather River are less suitable than those reported as optimal for known predators. In the absence of reliably quantified repeatable predation studies it does not appear likely that continued operation of the Oroville Facilities, under current operating practices, would create conditions favoring unnaturally high predation rates on juvenile anadromous salmonids.

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